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## Specification

### Devices for Controlling at Least one Register in a Printing Machine

The invention relates to devices for regulating at least one register in a printing press in accordance with the preamble of claim 1, 3 or 5.

A device for parallel image inspection and color regulation of a printed product produced in a printing press with at least one printing group is known from DE 43 21 177 A1, wherein an image detection arrangement is provided, which forwards image data from the printed product to a computer arrangement, wherein the image detection arrangement consists of one or several measuring modules, each of which scans a defined image area of the printed product, and of at least one associated receiving device, which creates the image data and preferably is spatially separated from the measuring modules, wherein the measuring modules and the at least one receiving device are connected with each other by means of at least one image conductor, wherein a register sensor is additionally provided, by means of which a register measurement can be performed at the imprinted printed product.

A color registration system for a printing press is known from EP 0 598 490 A1, wherein a computer with a camera or a group of cameras determines an erroneous alignment of colors of a printed product by comparing an actual image with a stored reference image, and by means of a printing control aligns a longitudinal, transverse and rotary position of

cylinders of a printing press in relation to a web, which is moved through the printing press and is to be imprinted, in such a way that the cylinders create a multi-color image with colors which are correctly aligned with each other.

A device and a method for the register-maintaining matching of printing cylinders of a web-fed rotary printing press is known from EP 0 882 588 A1, wherein a first cylinder imprinting one side of the web is driven by a first motor, and a second cylinder imprinting the same side of the web is driven by a second motor, and the angular position of the second cylinder is matched by a regulator to maintain registration with the first cylinder, wherein register markings imprinted by the cylinders on the web are recorded by a sensor arranged downstream of the last cylinder in the production direction, for example a CCD camera, and are evaluated as guide values for the regulator by means of characteristic lines.

The object of the invention is based on providing devices for regulating at least one register in a printing press.

In accordance with the invention, the object is attained by means of devices having the characteristics of claim 1, 3 or 5.

The advantages which can be attained by means of the invention reside in particular in that it is possible by means of providing images of the entire imprinting substrate width to simultaneously obtain several data for regulating the printing process in a single evaluating unit. Also, no separate types of sensors with associated separate evaluating units are required for the various regulating paths in the

printing press, instead, the image sensor alone provides the data required for several parameters which are relevant to the printing process in the printing press and can be influenced by control systems, such as adjusting the supply of ink or dampening agent, or the registration or registers, for example, which has advantageous effects on the cost for setting up and maintaining the regulating system, as well as on the speed of reaction in case of detected deviations from the regulation. Thus, the above mentioned parameters which are relevant to the printing process can be simultaneously controlled by a single regulating device having an image sensor and only one evaluating unit, and can be corrected if needed which, because of the rapid intervention and regulating possibilities, contributes to keeping the amount of waste in the printing process low and to assure a high production quality over the entire printing process. By means of the integral detection and evaluation of the data in a single evaluating unit or computing device, their logging, and documentation of the quality of the printed products going hand-in-hand with it, as well as statistic analyses regarding the printing process, are made easier because of the omission of interface problems which otherwise would have to be solved. Since preferably an image of every produced printed piece is recorded, a check of individual pieces takes place, and not only a spot check. Accordingly, a 100% check results during the printing process, wherein printed copies lacking quality can be removed or at least marked. Separate register markings, test fields or print control strips applied to the imprinting substrate in addition to the actual printed image are not required for regulating the color

density of a color applied to the imprinting substrate by the printing press, or for checking that the register of the printed image is maintained, which is advantageous, because for one, register markings require additional space on the material to be imprinted, and also register markings provide only an indirect reference to the actual position of the color components in respect to each other, which in their totality constitute the printed image.

An exemplary embodiment of the invention is represented in the drawings and will be described in greater detail in what follows.

In a greatly simplified representation, by way of example the single drawing figure shows four lined-up printing groups 01, 02, 03, 04 of an offset rotary printing press, each with a forme cylinder 06, 07, 08, 09, a transfer cylinder 11, 12, 13, 14, and a counter-pressure cylinder 16, 17, 18, 19, wherein every counter-pressure cylinder 16, 17, 18, 19 is preferably also embodied as a transfer cylinder for producing printed products imprinted on both sides and works together with a forme cylinder (not represented) assigned to it. An imprinting substrate 21, for example a printing sheet 21 or a web 21 of material, preferably a paper web 21, is passed between the transfer cylinder 11, 12, 13, 14 and the counter-pressure cylinder 16, 17, 18, 19 in the course of the printing process and is imprinted with at least one printed image. It is immaterial for the invention whether the printing groups 01, 02, 03, 04 are arranged in such a way that the imprinting substrate is conducted horizontally or vertically through the printing press.

An image sensor 22, for example a color camera 22, preferably a digital semiconductor camera 22 with at least one CCD chip, is preferably arranged at the outlet of the last printing group 04 in the transport direction of the imprinting substrate 21 of the printing press, and with its image-taking area is preferably directed immediately and directly onto the imprinting substrate 21, wherein the image-taking area of the image sensor 22 takes in at least the entire width of the imprinting substrate 21, wherein the width of the imprinting substrate 21 extends transversely to its transport direction through the printing press. Thus, the image sensor 22 detects an image of the entire width of the imprinted paper web 21 which can be electronically evaluated, wherein at least one printed image has been applied to the imprinting substrate 21 along the width of the paper web 21. The image sensor 22 is embodied, for example, as an area camera 22.

The image sensor 22 transmits the data correlated with the recorded image to a suitable evaluating unit 23, in particular a program-controlled electronic computer arrangement 23, which is arranged, for example, in a control console which is a part of the printing press. Parameters relevant to the printing process can now be checked by means of an analysis performed in the evaluating unit 23 and, if required, can be corrected automatically, so to speak, by means of programs run in the evaluating unit 23. The evaluation and correction of all parameters relevant to the printing process takes place here practically simultaneously by means of the same evaluating unit 23. In particular, the image detected by the image sensor 22 in the course of the

running production of the printing press and transferred in the form of a data flow to the evaluating unit 23 is evaluated to determine whether the printed image, which was actually recorded as the image and was evaluated, shows a change in the shading value in comparison with a previously recorded and evaluated printed image, in particular an increase in the shading value, i.e. an actually recorded image is checked during the running process by comparison with a reference image. If the result of the check is a change in the shading value, i.e. as a rule a technically unavoidable increase in the shading value, the metering and/or supply of ink to the printing press is changed by means of at least one first actuating command emanating from the evaluating unit 23, conducted via the data line 24 and acting on at least one of the printing groups 01, 02, 03, 04 to the effect that the shading change becomes minimal by the application of ink following the actually checked image. After the regulation of the color density performed following the change in metering and/or supply of ink, the color impression of an image following the actually recorded image of a printed image again corresponds better to a previously taken image of a printed image, i.e. the reference image. The control and regulation of the shading change is important for keeping the color balance, or the gray balance, and therefore the color impression of the produced printed products, as constant as possible - possibly within permissible tolerance limits -, which constitutes an important quality feature in connection with printed products.

The data flow generated from the recording of the printed image and transmitted to the evaluating unit 23 is employed in the same way for checking the maintenance of the registration of the printed image applied to the imprinting substrate 21, in particular for checking and, if required, the correction of a color registration of a printed image produced by multi-color printing. At least one register, preferably adjustable by means of a motor, is provided in the printing press, for example a circumferential register or a lateral register, if required a diagonal shifting device for at least one of the forme cylinders 06, 07, 08, 09 in respect to the transfer cylinder 11, 12, 13, 14 assigned to it, wherein, as a function of this check, the register is regulated by means of at least one actuating command emanating from the evaluating unit 23, transmitted via a data line 26 and acting on at least one of the printing groups 01, 02, 03, 04 to the effect that the greatest possible registration accuracy results for a printed image following the recordation of the evaluated image. Setting or adjustment of the registers is thus calculated by the evaluating unit 23 from the image data made available by the image sensor 22 of the evaluating unit 23. It is also possible by means of the setting or adjustment of the lateral registration to counteract a transverse stretching caused by fan-out, wherein this transverse stretching occurs in particular in printing presses having a so-called eight-tower structure of their printing groups.

Preferably the printing press is embodied to be without shafts. In such a printing press the forme cylinders 06, 07, 08, 09 preferably have individual drive mechanisms, which are

mechanically decoupled from the drive mechanisms for the counter-pressure cylinders 16, 17, 18, 19, so that the phase relation or angular relation of the forme cylinders 06, 07, 08, 09 in respect to the counter-pressure cylinders 16, 17, 18, 19 can be changed by appropriate control or regulation, preferably of the drive mechanisms of the forme cylinders 06, 07, 08, 09, whenever an evaluation of the image of the imprinting substrate 21 by means of the image sensor 22 makes this appear necessary. The entire image content, not only individual locally limited image elements of the imprinting substrate 21, such as the reference markers, for example, or similar, therefore affects the control or regulation of the printing group, in particular the drive mechanisms of the forme cylinders 06, 07, 08, 09.

An actuating command generated by the evaluating unit 23 on the basis of the image contents of the image taken of the printed image acts on a control device or regulating device of an electric motor, preferably a position-controlled one, for the rotatory driving during printing of at least one of the forme cylinders 06, 07, 08, 09, the transfer cylinder 11, 12, 13, 14 assigned to it, or the counter-pressure cylinder 16, 17, 18, 19. In this way the drive mechanism of the forme cylinder 06, 07, 08, 09 in particular, or of the transfer cylinder 11, 12, 13, 14 assigned to this forme cylinder 06, 07, 08, 09, in one of the printing groups 01, 02, 03, 04 of the printing press can be controlled or regulated, preferably by electrical signals, independently of the drive mechanism of the forme cylinder 06, 07, 08, 09, or of the transfer cylinder 11, 12, 13, 14 assigned to this forme cylinder 06, 07, 08, 09, in another one of the printing



groups 01, 02, 03, 04 of the printing press, in particular is it possible to set the mutual angular relation or phase relation of the forme cylinders 06, 07, 08, 09 or of their assigned transfer cylinders 11, 12, 13, 14, which are involved in the printing of the printed products, i.e. the printed image, and are arranged in different printing groups 01, 02, 03, 04 of the printing press, by means of the associated control device or regulating device, for example the evaluating unit 23, to a registration which is suitable for producing the printed product. The electric motor of the forme cylinder 06, 07, 08, 09 is preferably arranged coaxially in respect to the axis of the forme cylinder 06, 07, 08, 09, wherein the rotor of the motor is preferably rigidly connected with a journal of the shaft of the forme cylinder 06, 07, 08, 09 in the manner described in DE 43 22 744 A1. The counter-pressure cylinders 16, 17, 18, 19 arranged in the various printing groups 01, 02, 03, 04 of the printing press can, such as described in EP 0 812 683 A1, for example, be mechanically connected with each other by a train of gear wheels, for example, and have a common drive mechanism, for example, wherein, however, the forme cylinder 06, 07, 08, 09, or the associated transfer cylinder 11, 12, 13, 14, remain disconnected in regard to their drive mechanisms from their associated counter-pressure cylinder 16, 17, 18, 19. A coupling, for example by means of gear wheels in engagement with each other, can exist between the forme cylinder 06, 07, 08, 09, and the transfer cylinder 11, 12, 13, 14 assigned to it, so that the forme cylinder 06, 07, 08, 09, and the transfer cylinder 11, 12, 13, 14 assigned to it are driven by the same drive mechanism. The control

device or the regulating device of the drive mechanisms of at least the forme cylinders 06, 07, 08, 09 is integrated in the evaluating unit 23, for example.

The control or regulation of the phase relation or angular relation of the forme cylinders 06, 07, 08, 09 in respect to the counter-pressure cylinders 16, 17, 18, 19 takes place in respect to a fixed reference setting, so that the forme cylinder 06, 07, 08, 09 can have a leading or trailing relation in respect to the counter-pressure cylinder 16, 17, 18, 19 assigned to it, wherein the relation of the rotation of the forme cylinder 06, 07, 08, 09 and the counter-pressure cylinder 16, 17, 18, 19 assigned to it is set as a function of the image content of the image recorded by the image sensor 22, and is also updated by the control device or regulating device of their drive mechanisms. It is possible in the same way to control or regulate the phase relation or angular relation of forme cylinders 06, 07, 08, 09, which are arranged downstream of each other in the printing process, in respect to a fixed reference setting, which is of particular importance in connection with multi-color printing of printed matter printed according to colors in printing groups 01, 02, 03, 04 of the printing press arranged one behind the other. If it becomes apparent from the image of the printed image, which preferably has several colors, that a correction is required of one color used in one of the printing groups 01, 02, 03, 04, the evaluation unit 23 issues its actuating command, which counteracts the detected interference effects, to the respective printing group 01, 02, 03, 04.

If the actuating drives, which are to be regulated by the evaluating unit 23 by means of actuating commands, for example the actuating drives for regulating the supply of ink or of the dampening agent, as well as the drive mechanisms for regulating the circumferential register or the lateral register, are connected to a data network which is connected with the evaluating unit 23, the data lines 24, 26 provided for transmitting the first and second actuating commands are preferably realized by the data network.

The checking of a shading value change occurring during the printing process, and the check for maintaining registration are performed in the evaluating unit 23 by means of parallel data processing, advantageously simultaneously. These two checks are preferably continuously performed during the running printing process, in particular advantageously at the end of the printing process and also for each individual, produced printed copy.

Initially the check for maintaining registration relates to a congruent agreement of the position of the printed image or of the printed area between recto and perfecting printing, or also between the top and the underside when producing printing products imprinted on both sides. But the check also includes, for example, a check of the register, i.e. the check of the intended accuracy which individual partial have when printed on top of each other during multi-color printing. The registration accuracy, as well as the register accuracy, play an important role in multi-color printing.

An illuminating device 27, for example a flash lamp 27, is advantageously assigned to the image sensor 22, wherein

brief light flashes emanating from the flash lamp 27 make rapidly progressing movement actions, such as the printing process represents, appear to stand still by means of a stroboscopic method, and in this way make it observable to the human eye. With a sheet-fed printing press in particular, the recording of the printed image performed by means of the image sensor can also take place in or at a delivery device 28 of the printing press, which is shown in the drawing figure by a dashed representation of the image sensor 22 and the associated illuminating device 27 as a possible option for recording the printed image downstream of the last printing group 04 of the respective printed side, or at the end of the printing press. By means of an appropriate selection of the image sensor 22, and possibly of the associated illuminating device 27, it is possible to extend the recording of the image into a virtually non-visible range, such as the infrared or ultraviolet range, for example, or displace it into them. As an alternative to the preferred area camera 22 with a flash lamp 27, the employment of a line camera with a permanent illuminating device is also possible.

Since preferably every printed copy is subjected to a check, a trend can be recognized in the continuing printing process, i.e. during continued printing, toward shading value change and well as the maintenance of the registration of sequentially produced printed copies. Depending on the value of their shading and/or their associated registration detected during the running printing process, the printed copies can be classified into groups of different quality stages and can be marked as waste copies upon exceeding a

permissible tolerance limit. Waste copies can be specifically removed by the evaluating unit 23 or, in particular in connection with a sheet-fed printing press, can at least be placed on a separate deposit stack 29 in the delivery device 28. To this end at least one third actuating command, for example a waste signal, is issued by the evaluating unit 23 evaluating the image and is conducted over a data line 31 to at least one actuating drive acting on at least one arrangement for transporting the imprinting substrate 21 for sorting the flow of copies.

For synchronizing the frequency at which the recording of images on the imprinting substrate 21 takes place with the transport speed of the imprinting substrate 21, i.e. for example the speed of the paper web 21, an angle encoder 32 has been installed in at least one of the printing groups 01, 02, 03, 04, preferably in that printing group 01, 02, 03, 04 in or at which the recording of the images by means of the image sensor 22 takes place, wherein the operating angle encoder 32 has a fixed ratio in respect to the number of revolutions of that transfer cylinder 11, 12, 13, 14 at which the image sensor 22 records the images. The angle encoder 32 provides its output signal to the evaluating unit 23 and/or also to the image sensor 22. Inter alia, the output signal of the angle encoder 32 is employed as the trigger for the flash lamp 27.

The image recorded by the image sensor 22 and conducted in the form of a data flow to the evaluating unit 23 is preferably displayed on a monitor of an input and output unit 33, which is connected with the evaluating unit 23 and performs a bi-directional data exchange. The input and

output unit 33 also provides correction options for at least one of the mentioned regulating devices in that it makes possible manual input and/or the triggering of at least one actuating command.

The evaluating unit 23 has a memory device 34, inter alia for the storage of recorded image sequences, as well as for the storage of data which are useful for logging and simultaneous documentation of the quality of the printed products, as well as for statistical analyses of the printing process. It is advantageous if the evaluating unit 23 can make the data which are evaluated and/or stored in it available to a company network by means of an appropriate connector 36.

For the comparison, performed by the evaluating unit 23, of data which are correlated with an image actually recorded in the course of the running production of the printing press, with the data from a previously generated image, it can be provided that the data from the previously recorded image are correlated with an image recorded in a pre-printing stage arranged upstream of the printing press, wherein a data processing arrangement of the pre-printing stage (not represented) is connected with the evaluating unit 23 and provides the data of the previously generated image to the evaluating unit 23. In this way the data of the previously generated image are generated alternatively or additionally to the data which are correlated with an image recorded by the image sensor 22 and are made available to the evaluating unit 23. In comparison with data obtained in the running production of the previously imprinted images, data from the pre-printing stage and correlated with the printed

image constitute the better reference data for the control or regulation of the color register.

The proposed device allows a register regulation and color regulation on the basis of an analysis of the same image recorded with the image sensor 22, in that the image of the printed image is evaluated in regard to different parameters which are relevant to the printing process in a single evaluating unit 23, as well as simultaneously an inspection of the printed image for judging the quality of the printed matter.

In this case a register measurement in the printed image is the basis for the register regulation. After all colors required for the printed image have been imprinted, the entire printed image is recorded by the camera, preferably at the outlet of the printing press. A dissection of the recorded printed image takes place in the evaluating unit 23, preferably into the color components CMYK customary in printing technology, as well as an analysis of suitable portions of the printed image and a relative position determination of a color component in respect to a reference color component by means of correlation methods with a previously recorded or obtained printed reference image.

The reference image is obtained, for example, either from the pre-printing stage, which has the advantage that the reference image is already available in the individual color components, or a reference image, for example a printed sheet containing the printed image from a proof of the printed image, is used for the evaluation, wherein this reference image must additionally still be separated into the color components. This reference sheet is recorded after the

printed image has been manually adjusted once in such a way that all printed printing colors are correctly positioned in relation to each other and in this way a proper color register has been set. This printed reference image obtained in this way can be stored for later repeat orders, so that in case of a repeated order this previously recorded reference image can be accessed. By means of assessing the stored printed reference image it is also possible for the evaluating unit 23 to set the color register automatically without manual intervention which, in case of a repeat order, leads to a further reduction of waste.

Characteristic and suitable portions of the printed reference image are selected, by means of which the position of the individual color components in respect to the reference color component is determined. This is the so-called desired position for the subsequent register comparison. This reference image, including the color components and the desired position, is stored in the memory device 34, for example. The selection of the suitable printed image portion can take place manually by the operator or automatically by the evaluating unit 23, for example by pre-setting the desired position. Areas in which the printing ink to be measured dominates or appears exclusively are suitable printed image portions in regard to the register measurement.

Each printed image is recorded during the running printing process, i.e. continuous printing, by means of the camera system and separated into the color components CMYK. Now the position of the individual color components within the previously selected suitable printed image portions is



determined. This takes place by a comparison with the color components from the printed reference image, for example by means of a correlation method, in particular a cross-correlation method. It is possible by means of the correlation method to determine the position of the color components within approximately 1 pixel of the camera resolution. If a stationary register offset is repeatedly determined for each printed sheet, a high degree of accuracy of the measured value is assured by the suppression of stochastic scattering.

The determination of the position of the individual color components takes place in the web running direction in accordance with the longitudinal register, and in the transverse direction in respect to the web running direction in accordance with the lateral register. The position differences obtained in this way are converted by the evaluating unit 23 into actuating commands and are transmitted as correction signals to the adjusting system, i.e. the drive mechanisms.

In offset printing special colors are not mixed with the standard colors, i.e. the scale colors CMYK, but are printed separately. Therefore special colors are also separately measured. First it is necessary to determine the areas in which special colors are to be printed. Now their own suitable areas are fixed for each special color, in which the position of the color component is determined in the same way as for the scale colors CMYK, i.e. the standard colors. The further procedure for register regulation in connection with special colors is identical to the previously described procedure for standard colors.

26	Data line
27	Illuminating device, flash lamp
28	Delivery device
29	Deposit stack
30	-
31	Data line
32	Angle encoder
33	Input and output unit
34	Memory
35	-
36	Connector to a company network

## List of Reference Symbols

01	Printing group
02	Printing group
03	Printing group
04	Printing group
05	-
06	Forme cylinder
07	Forme cylinder
08	Forme cylinder
09	Forme cylinder
10	-
11	Transfer cylinder
12	Transfer cylinder
13	Transfer cylinder
14	Transfer cylinder
15	-
16	Counter-pressure cylinder, transfer cylinder
17	Counter-pressure cylinder, transfer cylinder
18	Counter-pressure cylinder, transfer cylinder
19	Counter-pressure cylinder, transfer cylinder
20	-
21	Imprinting substrate, printed sheet, web of material, paper web
22	Image sensor, color camera, area camera, semiconductor camera
23	Evaluating unit, computing device
24	Data line
25	-